National Aeronautics and Space Administration

GRADES K-4

Space Shuttle Tires

structures and materials

Aeronautics Research Mission Directorate

Museum in a BOX Series

Space Shuttle Tires

Lesson Overview

In this lesson, students will compare tires from three different vehicles: a bicycle, a truck and the Space Shuttle. They will explore the structure of the tires, discovering the similarities and differences between them. They will also compare the tires of several passenger vehicles and discover how the size of the tire directly relates to the size of the vehicle.

(Photo courtesy of the Dryden Flight Research Center)

Space Shuttle Columbia's first landing was at NASA's Dryden Flight Research Center, located at Edwards Air Force Base, CA.

Objectives

Students will:

1. Identify the parts of each tire and note their differences by observing the tire sections from the Space Shuttle, a truck and a bicycle.
2. Identify the information stamped on the sidewalls of tires found on vehicles in a parking lot.

Materials:

In the Box

Space Shuttle tire section
Truck tire section
Bicycle tire section

Provided by User

None

GRADES **K-4** **Time Requirements:** 2 hours

Background

Landing the Shuttle

Although the Space Shuttle departs Earth vertically as a rocket, it lands horizontally, like an airplane. This requires a landing gear system comprised of struts, shock absorbers and most importantly to these activities, tires. The Shuttle normally lands at the Kennedy Space Center in Florida, using Edwards Air Force Base in California as an alternate runway during periods of unsuitable weather.

To land, the orbiter (which is the part of the Space Shuttle remaining after the solid rocket boosters and fuel tank have jettisoned upon launch), aligns with the runway. It begins a steep descent with its nose angled as much as 19 degrees down from horizontal. This 'glide slope' as it is known is nearly seven times steeper than the average commercial airliner landing which causes the Shuttle to descend toward the runway approximately 20 times faster. At about 610 meters (2,000 feet) above the ground, the Shuttle commander raises the nose, which slows both the rate of descent and airspeed in preparation for touchdown. At approximately 75 meters (250 feet) above the ground, the speed will have slowed to less than 556 km/hr (300 kts/345mph) and the landing gear is deployed and locked into place.

At touchdown, the main landing gear tires contact the runway first at approximately 354 km/hr (191 kts/220mph). Next, the nose gear lowers slowly as the orbiter loses speed. If necessary, a drag shoot can be deployed to assist in slowing the orbiter as well as maintaining directional control down the runway.

Shuttle Tires

The Shuttle has two main landing gear, which consist of two tires each. There are also two tires on the nose landing gear, for a total of six tires.

Like most aircraft tires, the Space Shuttle tires are filled with Nitrogen because of its stability at different altitudes and temperatures. Also, Nitrogen molecules are larger than Oxygen molecules, which means Nitrogen escapes less easily from the tires, resulting in a more gradual loss of pressure over time. Nitrogen is also non-flammable which prevents problems should a tire puncture upon landing.

When landing, the orbiter weighs approximately 109,000 kg (240,000 lbs). Because of this, shuttle tires are inflated to a much higher pressure than a small airliner or car. The main gear tires are inflated to 315 psi while the nose gear is inflated to 300 psi. The main gear tires can only be used one time, while the nose gear tires can be used for two landings.

Tire Basics

Every tire manufactured in the United States is required to have its designation stamped into the sidewall of the tire.

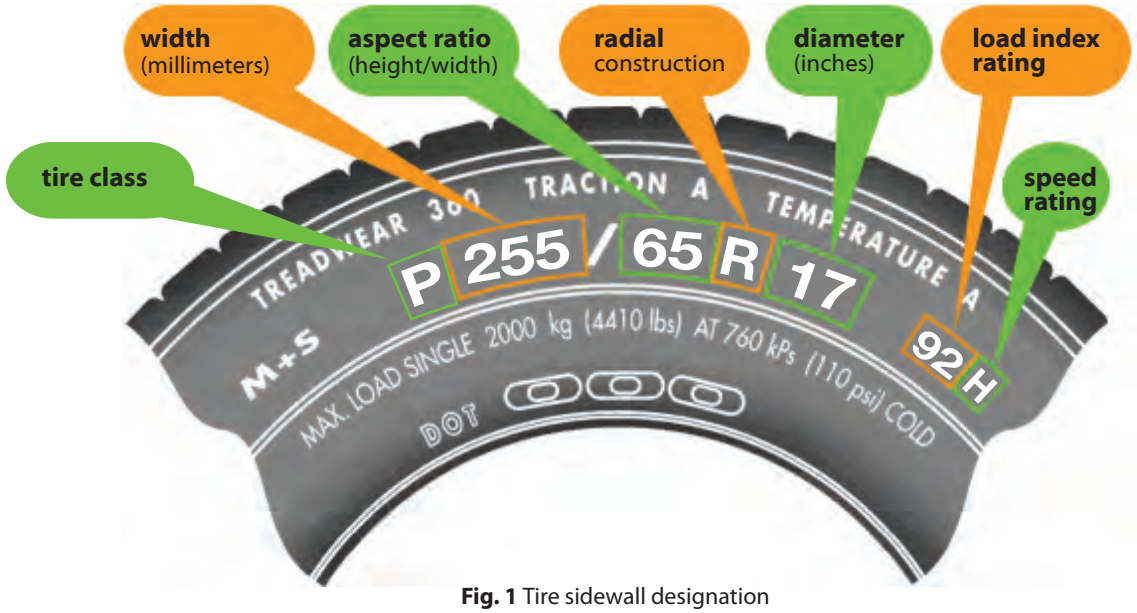


Fig. 1 Tire sidewall designation

In this example you can see the following designation on the tire: P255/65R17 92H

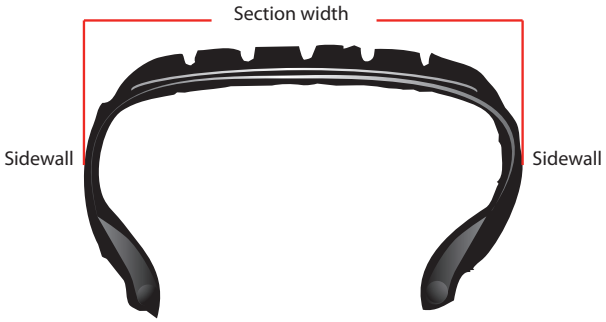


Fig. 2 Tire cross section

- **P** designates the tire's class. In this example, "P" indicates that the tire is a passenger car tire. An "LT" would designate it as a light truck tire.
- **255** is the tire's section width measured in millimeters. This measurement is taken from sidewall to sidewall. In this example, the section width of the tire is 255mm.
- **65** is the aspect ratio of the tire. The aspect ratio refers to the height of the sidewall as a percentage of the section width.
- **R** refers to the tire construction. In this example the tire is a radial tire. Although rare, you may also see the letter C, which refers to a cross-ply tire.
- **17** refers to the wheel diameter in inches.
- **92** refers to the load index for the tire. Load index ranges from 0 to 279 and corresponds with the load-carrying capacity of a tire. Passenger car tire load indices typically range from 75 to 105. (See the Load Index Table, Fig. 10 in the Reference Material Section.)
- **H** indicates the speed rating for the tire, which is the maximum speed for which the tire is allowed to travel per the manufacturer's recommendation.

Activity 1 Comparing Tires

GRADES K-4

Time Requirement: 60 minutes

Materials:

In the Box

Tire Sections:
Space Shuttle
Truck
Bicycle

Worksheets

None

Reference Materials

None

Key Terms:

Bead
Chafer
Filler
Liner
Nylon Belt
Plies
Sidewall
Steel Belt
Tread

Objective:

Observing the tire sections from the Space Shuttle, a truck and a bicycle, students will identify the parts of each tire and note their differences.

Img. 1 Tire Cross Sections

Activity Overview:

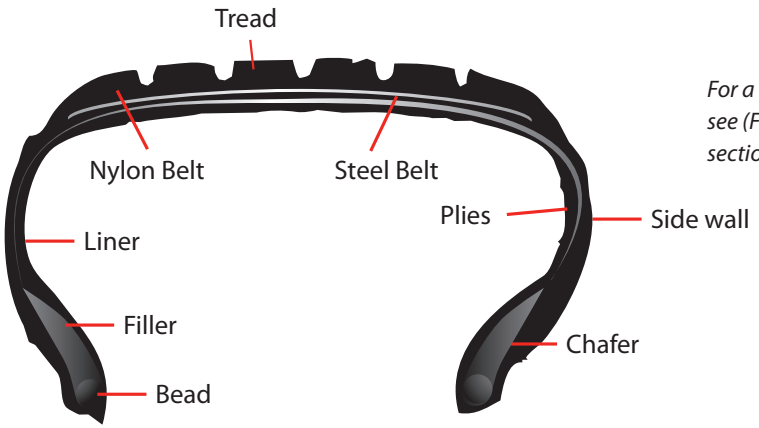
In this activity you will use the pieces of tire provided to explore the differences between tires used on three different vehicles: a bicycle, a pickup truck and the Space Shuttle. You can either keep the students in one group or divide them into three groups, with each group getting a tire section.

Fig. 3 Tire with cross section

Activity:

1. **Examine the three tires provided (shuttle, truck, and bicycle).**
   Hold up each piece of tire and tell the students which one belongs to which vehicle. Explain that each piece of tire is just a cross-section of the entire tire. (A cross-section is a slice of tire cut perpendicular to the wheel and extracted from the whole tire so we can easily see what the tire is made of and how it is constructed). Using the "Tire Cross-Section" (Fig. 3) diagram, demonstrate how the cross-section relates to the whole tire.

2. **Identify the parts of each tire.**
   Using the Space Shuttle tire, along with (Fig. 4) in the Reference Materials section, explain to the students the purpose for each part of the tire.



For a list of terms and definitions, see (Fig. 4) in the reference materials section

Fig. 4 Parts of a tire

3. **Compare and contrast the parts of the three tires.**
   a. *Pass the tire pieces around so that every student has the opportunity to feel and see each piece.*
   b. *Encourage students to examine the tires closely and to take note of similarities and differences.*
   c. *Point out that some tires have components that others do not. For example, the bicycle tire has a bead, but not a steel belt.*
   d. *Suggest the students think about the vehicle each piece of tire supports while they are examining its tire.*
   e. *If necessary, point out that larger/heavier vehicles require larger tires.*

Discussion Points:

1. **How are the tires similar? How are they different?**
   If you have access to a white board, chalk board or large pad of paper, create a list of the similarities and differences between the tires.

2. **Why is the shuttle tire so much bigger than the bicycle tire?**
   The tires on the shuttle must be larger than those on a bicycle in order to support the extra weight; the shuttle is a much heavier vehicle.

3. **Name some other items that use rubber tires.**

NATIONAL SCIENCE STANDARDS K-4

SCIENCE AS INQUIRY

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

PHYSICAL SCIENCE

- Property of objects and materials

SCIENCE AND TECHNOLOGY

- Abilities of technological design
- Understanding about science and technology

NATIONAL MATH STANDARDS K-4

NUMBER AND OPERATIONS

- Understand numbers, ways of representing numbers, relationships among numbers, and number systems
- Understand meanings of operations and how they relate to one another

MEASUREMENT

- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurements

DATA ANALYSIS AND PROBABILITY

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them

PROCESS

- Problem Solving
- Communication
- Connections
- Representation

Activity 2 Parking Lot Research

GRADES **K-4**

Time Requirements: 60 minutes

Materials:

In the Box

None

Provided by User:

Cars and other vehicles in a parking lot

Long strips of paper (4 per student)

Worksheets

Vehicle Data Sheet (Worksheet 1)

Reference Materials

None

Key Terms:

Sidewall

Load Index

Objective:

Students will identify the information stamped on the sidewalls of tires found on vehicles in a parking lot.

Activity Overview:

In this activity, students will compare the sidewall designations of tires found on several passenger vehicles. Prior to beginning the lesson, review your facility's safety procedures with the students.

Activity:

The information on a vehicle's tire can explain a lot about the vehicle. Begin this activity by reviewing the Tire Basics section of this lesson with your students to ensure they are familiar with how to read a tire's sidewall information.

1. **Divide the class into teams.**
   Divide students into groups of 3-5 to perform their parking lot research. Make sure there are multiple vehicles in the parking lot to use as research subjects.

2. **Depending on the age and ability of the students perform one of the following steps.**
    a. Using the Vehicle Data Worksheet, have each team collect the Vehicle Type, Make, Model and Sidewall Numbers from several vehicles.

Img. 2 Tire Sidewall

    b. Using the strips of paper, have students measure the diameter of the tires of several vehicles by tearing the paper to length. If able, write on the strip of paper the make and model of the vehicle.

Discussion Points:

If step 2a was performed:

1. **Discuss what each of the sidewall numbers means, using one of the collected datasets as an example.**
   You can use the Tire sidewall designation (Fig. 1) as well if required to assist in the review.

2. **Is there any correlation to the specifications of the tire compared to the size of vehicle?**
   It should be noticed that in general, larger tires are used on larger vehicles. Also, trucks will typically have deeper treads than passenger cars of the same size, as trucks need additional traction when working off-road.

3. **Did any of the vehicles have the same tire dimensions?**

If step 2b was performed:

1. **Have the students compare their strips of paper with others. Are some the same length? If so, why?**
   It should be discovered that similar sized vehicles use similar sized tires.

2. **Was the Space Shuttle tire bigger or smaller than the tires they looked at? If so, why?**
   The vehicle tires will be considerably smaller than the Space Shuttle tire. This is because the vehicle tires have to support much less weight and operate at slower speeds.

NATIONAL SCIENCE STANDARDS K-4

SCIENCE AS INQUIRY

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

PHYSICAL SCIENCE

- Property of objects and materials

SCIENCE AND TECHNOLOGY

- Abilities of technological design
- Understanding about science and technology

NATIONAL MATH STANDARDS K-4

NUMBER AND OPERATIONS

- Understand numbers, ways of representing numbers, relationships among numbers, and number systems
- Understand meanings of operations and how they relate to one another

MEASUREMENT

- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurements

DATA ANALYSIS AND PROBABILITY

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them

PROCESS

- Problem Solving
- Communication
- Connections
- Representation

Reference Materials

Fig. 1 Tire sidewall designation

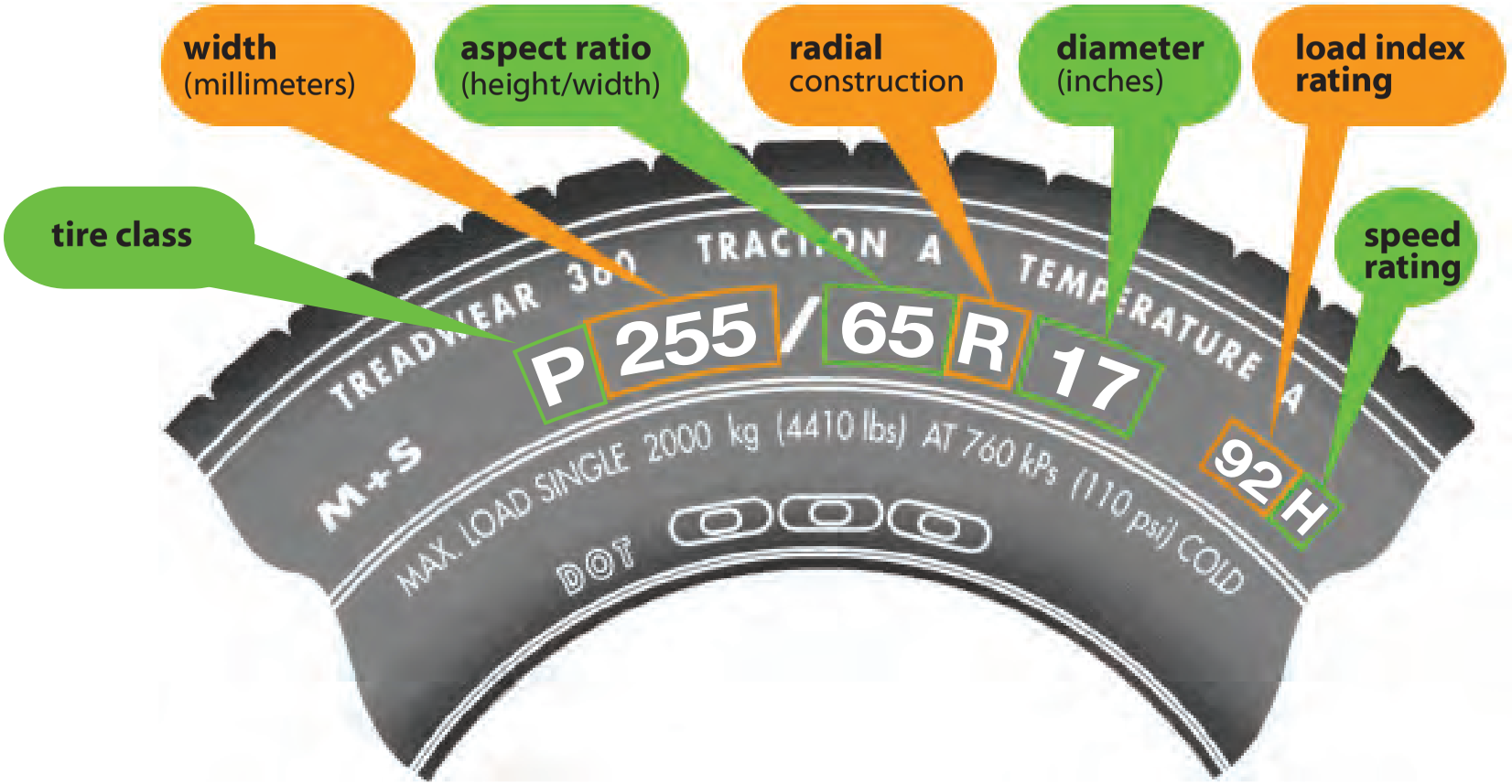


Fig. 2 Tire cross section

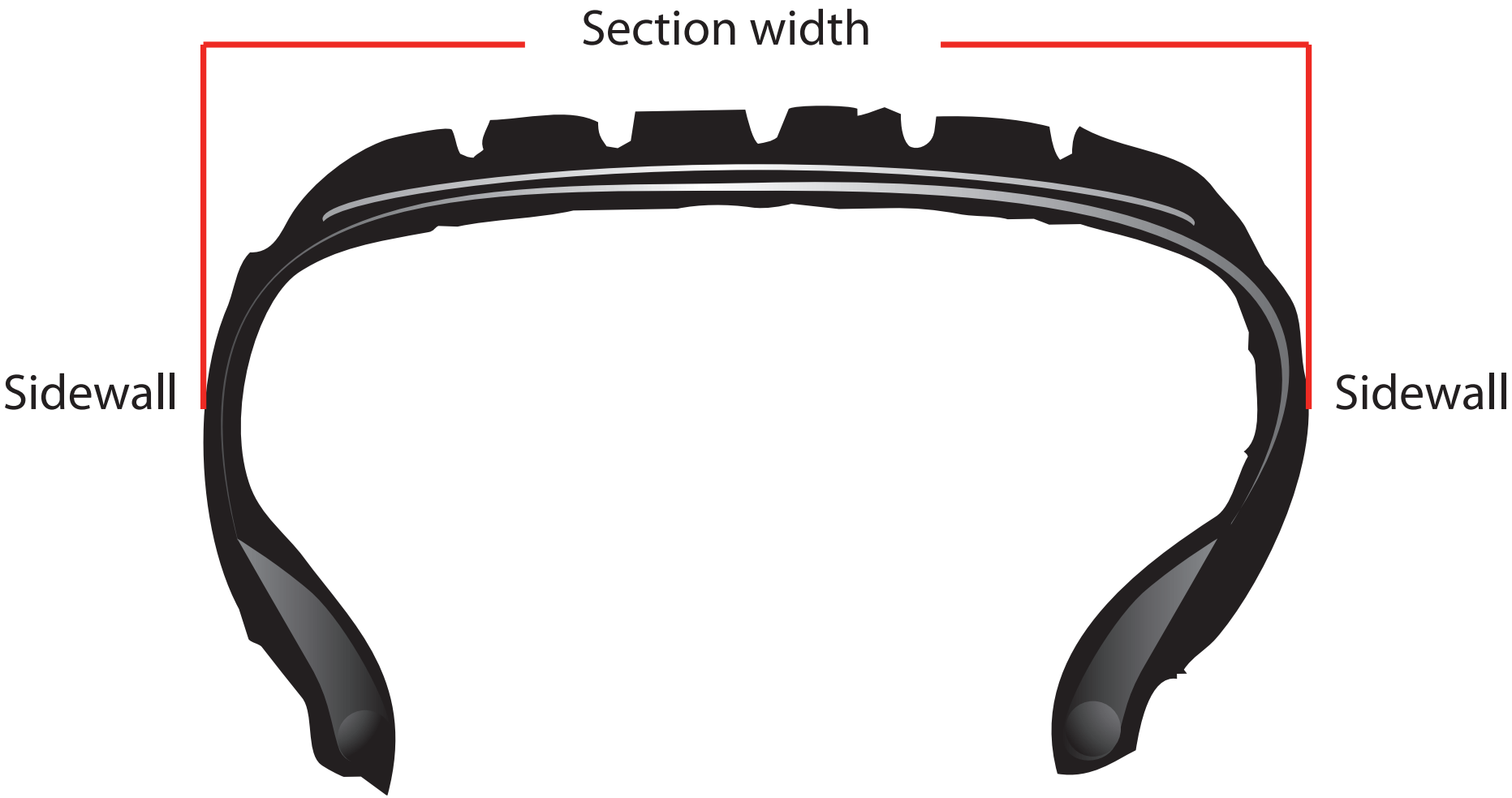
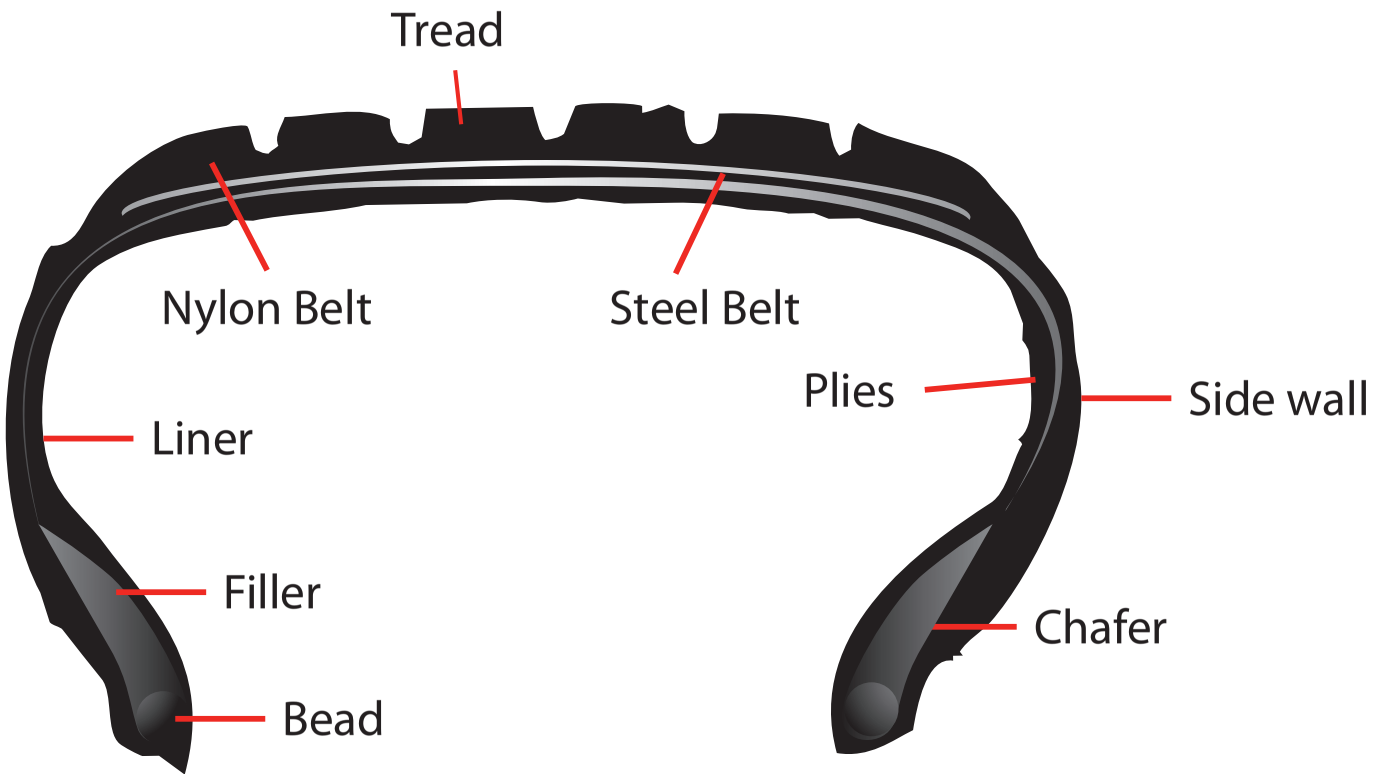


Fig. 3 Tire with cross section

Fig. 4 Parts of a tire



Bead
A mix of high-strength steel wire and rubber that hold the plies and the tire assembly onto the rim of the wheel.

Belt (Nylon and Steel Belts)
Narrow layer of coated tire cord or rubber-encased steel cord located directly under the tire tread that are designed to resist deformation.

Chafer
A layer of rubber compound that is applied to the bead; the chafer provides protection against rim chafing and other external damage.

Filler
A rubber compound that smoothly fits the plies to the bead.

Liner
A thin layer of rubber inside the tire which contains compressed air. Some tires use a tube in place of the liner.

Plies
Layers of fabric cord extending from bead to bead that reinforce the tire.

Sidewall
The part of the tire between the bead and the tread.

Tread
The most recognizable part of the tire. It is composed of a wear-resistant rubber compound that provides traction and assists in removing road surface water and contaminants.

Glossary

Bead:
A mix of high-strength steel wire and rubber that hold the plies and the tire assembly onto the rim of the wheel

Belt:
Narrow layer of coated tire cord or rubber-encased steel cord located directly under the tire tread that are designed to resist deformation

Chafer:
A layer of rubber compound that is applied to the bead; the chafer provides protection against rim chafing and other external damage

Filler:
A rubber compound that smoothly fits the plies to the bead

Liner:
A thin layer of rubber inside the tire which contains compressed air; some tires use a tube in place of the liner

Load Index:
The maximum load each tire can carry

PSI:
Pounds per Square Inch; one psi is one pound of force applied to one square inch of surface material

Plies:
Layers of fabric cord extending from bead to bead that reinforce the tire

Sidewall:
The part of the tire between the bead and the tread

Tread:
The most recognizable part of the tire. It is composed of a wear-resistant rubber compound that provides traction and assists in removing road surface water and contaminants

Tire Class:
The group or category to which the tire belongs (ex: P=Passenger, LT=light truck)

Tread Depth:
The distance from the top of the tread to the bottom of the grooves

Tread Life:
The number of miles the tread on a tire is expected to last

Student Worksheets

Worksheet 1

Vehicle Data

Vehicle Type	Make	Model	Sidewall Numbers
Car	Dodge	Neon	185/60R15

Images

Img. 1 Tire Cross Sections

(Photo courtesy of Lost Tribe Media, Inc.)

Img. 2 Tire Sidewall

(Photo courtesy of Lost Tribe Media, Inc.)

Img. 3 Installing a main shuttle tire

(Photo courtesy of NASA – www.nasaimages.org)

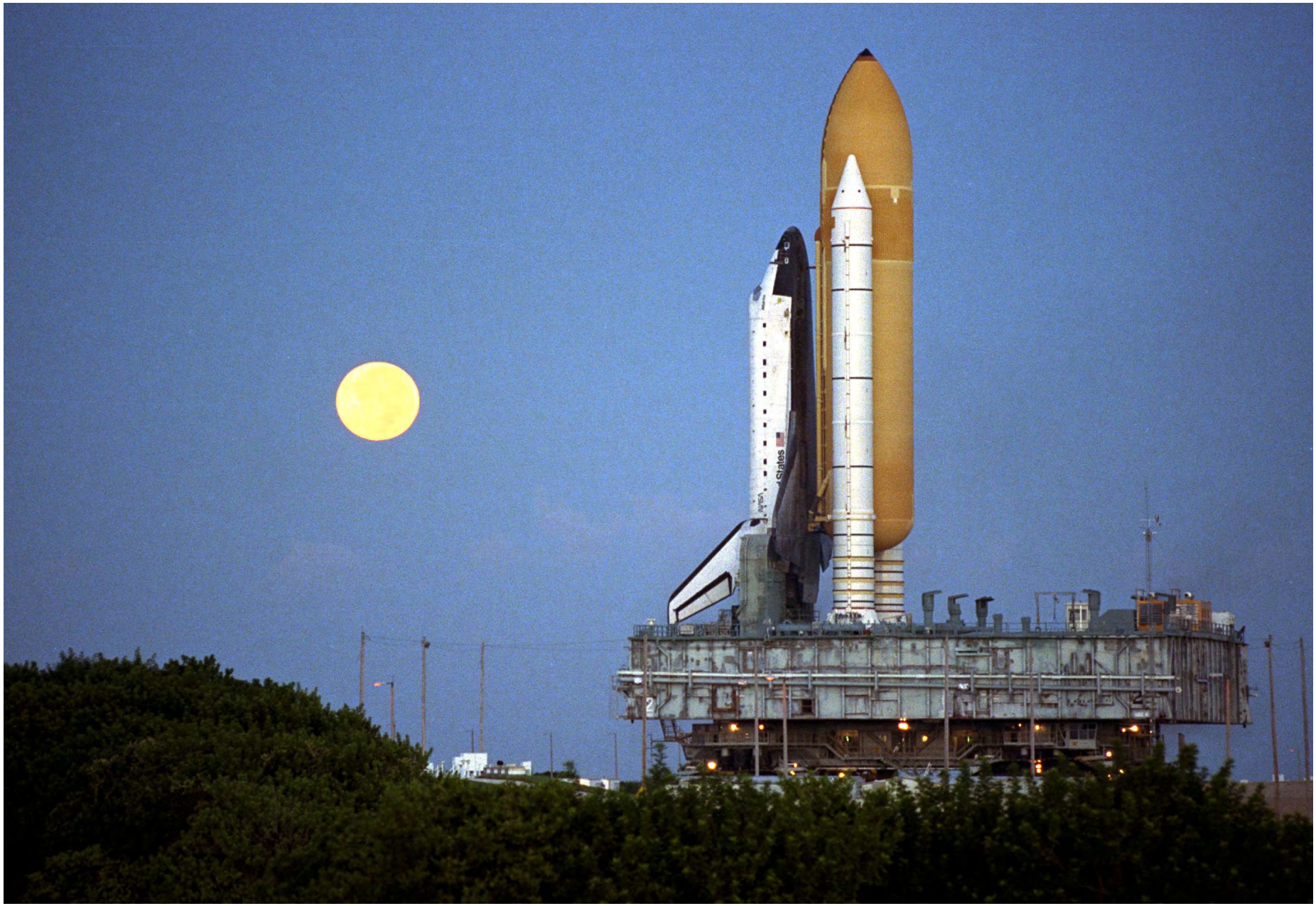
Img. 4 The Space Shuttle at lift-off

(Photo courtesy of NASA – www.nasaimages.org)

Img. 5 The Space Shuttle en-route to the launch pad

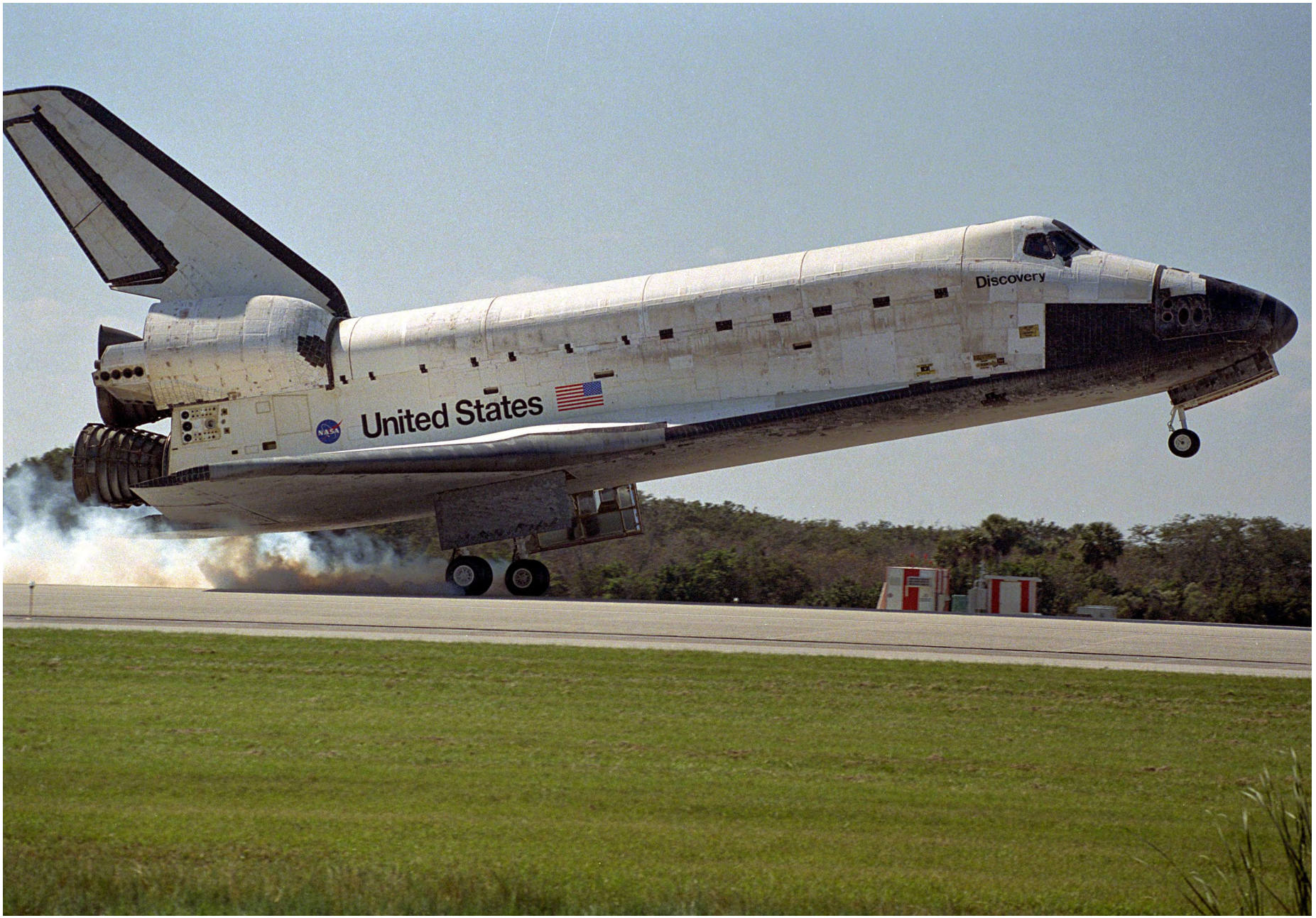
(Photo courtesy of NASA – www.nasaimages.org)

Img. 6 The Space Shuttle on the launch pad



(Photo courtesy of NASA – www.nasaimages.org)

Img. 7 The Shuttle Discovery landing at Kennedy Space Center



(Photo courtesy of NASA – www.nasaimages.org)

Img. 8 The Shuttle Endeavour landing at Kennedy Space Center

(Photo courtesy of NASA – www.nasaimages.org)

Img. 9 The Shuttle Columbia landing at Edwards Air Force Base

(Photo courtesy of NASA – www.nasaimages.org)

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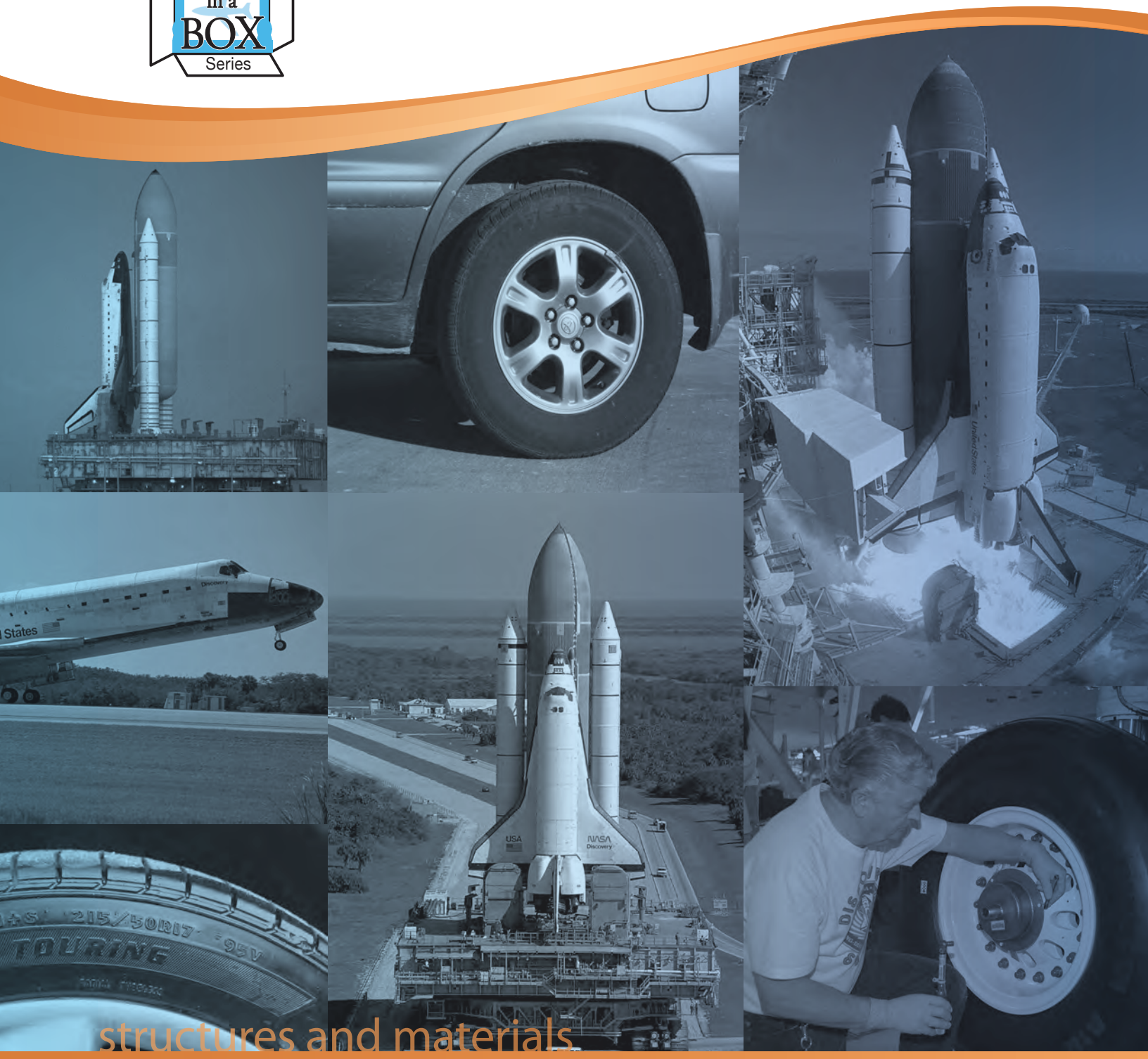

structures and materials

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